# Appendix C
# Benefit Cost Analysis

# Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study – Draft

PREPARED FOR: Mark Oliver/RDD
Maurice Hall/RDD

PREPARED BY: Nancy Lee/SAC

COPIES: Steve Cowdin/California Department of Water Resources
Allan Highstreet/SAC
Ken Iceman/RDD
Mary Jo Kealy/PHL
Sandy Taylor/SAC

DATE: November 12, 2004

## Introduction

This benefit/cost analysis (BCA) was developed as part of a feasibility analysis for the Colusa Basin Drainage District (District) Integrated Watershed Management Plan. Structural and nonstructural flood control measures were proposed for the City of Willows in Glenn County to alleviate periodic flooding. The structural measures include the North Fork Willow Creek detention basin, Wilson Creek detention basin, rice field spreading basins, stream restoration-Upper Watershed, stream restoration-Valley Floor, and ring levee. The nonstructural measures include rangeland revegetation with native grasses, reforestation of woodlands with native oaks, and floodplain management such as raising existing residential structures to avoid or minimize flood damage. The project alternatives identified in the July 2003 Draft Environmental Impact Report (EIR) are the structural flood control measures, nonstructural measures, and combined structural and nonstructural measures.

A final element of the watershed management plan is environmental enhancement within the watershed. Where possible, the flood control measures include environmental including enhancements such as designing the detention basins to include seasonal wetlands and augmenting the rice field spreading basins with riparian habitat. Standalone environmental enhancements were also proposed. Although the standalone measures do not control flooding directly, they can over time increase the ability of the soil to retain water, decrease the velocity of runoff, and, in the case of wetlands, benefit from seasonal flooding.

Benefit/cost ratios were developed for different combinations of the flood control measures and for individual measures, as follows:

- Structural measures (without the ring levee)
- Nonstructural measures (without the floodplain management)

- Combined structural and nonstructural (without the ring levee and floodplain management)
- South Fork Willow Creek and the Wilson Creek detention basins
- Ring levee
- Floodplain management
- Environmental enhancements
- Each of the above combinations in conjunction with the environmental enhancements

General categories of benefits that were estimated are habitat services, recreation, and avoided flood damages. Categories of costs include capital (construction, land, materials, equipment, and labor) and annual operating and maintenance (O&M) costs for the habitat restoration and flood control facilities. When possible, a range of benefits and costs was estimated to demonstrate a range of benefit to cost ratios. The habitat and recreation benefits and construction and O&M costs were estimated by individual flood control measures and aggregated accordingly for the combinations of flood control measures in this BCA. The avoided flood damages were modeled for each combination of measures or for individual measures.

The remainder of this technical memorandum documents the rationale and assumptions for the BCA.

# General Assumptions

## Project Duration, Constant Dollars, and Discount Rate

The BCA was conducted under a set of general assumptions. The project life was assumed to be 50 years with construction starting and ending in 2006. The first year of project operation would be 2007, and the last year would be 2056. All benefits and costs are expressed in July 2004 dollars unless otherwise noted. If a cost estimate did not have a month associated with it, it was assumed to be in June dollars of the corresponding year to reflect a mid-year price.

The McGraw Hill Engineering News-Record Construction Cost Index (CCI) was used to adjust construction and O&M-related costs to July 2004 dollars. The Bureau of Labor Statistics Consumer Price Index-All Urban Consumers, All Items (CPI) was used to adjust nonconstruction and non-O&M-related dollars, such as habitat and recreation values.

The federal discount rate was assumed to be 5 5/8 percent, which is the fiscal year 2004 rate used by the U.S. Army Corp of Engineers (USACE) and is considered by the USACE as a real rate (USACE, 2004). Because a real discount rate is used, the benefits and costs were not increased over the 50-year life of the project in an attempt to capture any inflation or escalation effects[1]. The federal discount rate was used to make this analysis more amenable to potential federal programs and funding partners.

[1] If a nominal discount rate (one that includes the effect of inflation) were used, then inflation and escalation would be included in the BCA.

Discount rates of 2 5/8 percent and 8 5/8 percent were also used to test the sensitivity of the analysis. Results are reported in this technical memorandum, but the focus of the Feasibility Study is on results based on the federal discount rate.

## Benefits

Three types of benefits were identified for each flood control measure. They are habitat services, recreation, and avoided flood damages. The economic value of recreation and avoided flood damages are values that can be observed in the marketplace. For example, consumers pay to travel to a recreation site or they pay a user fee to participate in certain recreation activities. With flood damages, property must be repaired or replaced at market prices for materials and labor. The economic value of habitats is more difficult to observe because markets for habitat services do not always exist. However, nontraditional markets, such as mitigation banks discussed below, have emerged as markets for environmental goods and services.

### Measuring Economic Value

Willingness to pay is a theoretically correct, market-based measurement of value and is defined as the maximum amount of money a consumer is willing and able to pay rather than go without a certain good or service (Freeman, 1993). The price a consumer pays to obtain a good or service is not necessarily the value of the good. The total value of a good to a consumer is the price paid plus the consumer surplus. Consumer surplus measures the difference between the maximum a person is willing to pay for a good and the amount he/she actually pays. Take the following example: (1) a consumer is willing to pay a maximum of $30 for the latest best-selling novel; (2) the publisher's suggested retail price for the book is $27; (3) the consumer finds the book on sale at a local bookstore for $25. If the consumer pays the $27, then the consumer surplus is $3 and the consumer is better off by $3 because he or she was willing to pay $30. If the consumer pays the $25, then the consumer surplus is $5 and the consumer is better off by $5. In either case, the value of the book is $30 and therefore, the higher price captures more of the value of the book to the consumer.

### Habitat Services

The environment provides services that benefit humans. For example, wetlands can improve water quality by giving sediment a chance to settle before the water moves farther down the watershed. Native habitats can help increase biodiversity, including special-status species or threatened and endangered species. These habitat services are generally known as indirect uses. Humans benefit from these services, but indirectly because they are provided through ecological processes. In contrast, services such as recreation are enjoyed directly.

The value of these habitat services could be individually quantified in monetary terms, but this would require data not readily available and, thus, was beyond the scope and resources available for conducting this BCA. Therefore, the value of individual habitat services was assumed to be subsumed in the habitat's overall value. Habitat values in this BCA were estimated using mitigation bank prices and imputed willingness to pay.

### Nontraditional Markets: Mitigation Banks

For many types of habitats, such as wetlands, forests, and endangered species habitats, nontraditional markets or "credit banks" have emerged for restoring, enhancing, and preserving acres of habitat. Such markets, although regulatory driven and sometimes influenced by the demand for development, are legally recognized and are intended to protect the full suite of ecological services that habitats provide (State of California, 2000; Boyer and Polasky, 2004). That is, they are intended to reflect the public's willingness to pay for ecological services that are not reflected in traditional markets (Boyer and Polasky, 2004). Under these circumstances, the prices that are paid for mitigation or conservation[2] credits can be a reasonable proxy for their economic value. Such credit prices can often provide a more comprehensive estimate of the combined values of the indirect services provided by such habitats than the more piecemeal approach of separately valuing each of the indirect services.

Mitigation and conservation bank credit prices reflect both market supply (i.e., cost) and market demand (i.e., willingness to pay) conditions. Purchasers of credits are at least willing to pay the price of a credit, or they would forego the credit or create and maintain their own mitigation habitat. Therefore, it is a maintained assumption of this analysis that these credit prices are an upperbound estimate of willingness to pay. That is, the combined value of ecological services provided by wetlands, riparian streams, and endangered species habitat do not exceed the prices for wetlands and conservation bank credits.

Recent studies have used conservation bank prices as estimates of habitat value. One project is a U.S. Department of Defense Air Force Base natural resources inventory and economic valuation expressed in monetary terms, including using the mitigation bank market approach, and ecological units (CH2M HILL, 2004a). Another project is a confidential powerplant application in the Northeast that used wetland and stream mitigation bank credit prices to value wetlands preservation and stream restoration (CH2M HILL, 2004b).

### Imputed Willingness to Pay

Imputed willingness to pay was a second method used in this analysis to estimate habitat benefits. This method assumes that the value of the proposed habitat is at least equal to the costs incurred by others to produce similar habitat. Using this method, lowerbound benefit values were estimated. The lowerbound estimates were based either on (1) actual and estimated expenditures to create similar types of habitat in the Natomas Basin, or (2) where similar projects could not be found, estimates were based on the estimated construction and O&M costs of the proposed flood control measure. However, as discussed above, expenditures may not fully capture willingness to pay for habitat services; therefore, these are viewed as lowerbound benefit values.

The imputed willingness-to-pay method is often used to compare water supply projects. It assumes the amount of water to be developed will provide a certain level of benefits and that a set of alternatives is available to develop the identified water supply. The least costly of those alternatives would be identified and implemented as the project; and therefore, the

---

[2] Mitigation banks are used to mitigate habitat impacts. For example, the adverse wetland impacts from development may be mitigated by purchasing wetland credits at a mitigation bank. Conservation banks preserve unique habitat that is sometimes associated with endangered or threatened species.

benefits of the water are equated with the cost of developing the water. For a necessary good such as water, it is reasonable to assume that the public is at least willing to pay the amount that corresponds to the least-cost alternative rather than do without water. This process can be viewed as a cost-effectiveness methodology, but was used in this BCA to estimate the lower bound of the habitat benefits. That is, the value of the habitat is assumed to be worth no less than the cost to create and maintain it.

For goods and services such as protecting and restoring habitats and their associated ecological services, the justification for using the imputed willingness to pay as a lowerbound estimate is based on the body of wetlands valuation literature (King and Bohlen, 1994). This literature shows a wide range in wetland values per acre depending on both the ecological and the human landscapes (Heimlich et al., 1999). For wetlands providing ecological services that are highly valued by the public and are relatively inexpensive to construct or restore, the imputed willingness-to-pay method would provide a lowerbound estimate of habitat value.

## Data Sources

The estimated lowerbound habitat values were based on two primary sources of data. The first was the range of actual and estimated wetlands and riparian construction, and O&M costs from the Natomas Basin wetlands projects (Wildlands, Inc., 2003). These projects are constructed wetlands and riparian habitats from existing rice fields and creek riparian areas. The Colusa Basin projects also propose creating wetlands and riparian habitat in a similar manner. The second was engineering cost estimates developed for this project (CH2M HILL, 2003).

The estimated upperbound habitat values used in this BCA are from the Wildlands, Inc., Sheridan bank. The Sheridan bank's service area contains a large portion of the District watershed, including the valley areas where wetlands would be well suited and the riparian areas along the Sacramento River and its tributaries (U.S. Fish and Wildlife Service, 2004). The intersection of the Sheridan bank service area and the Study Area is an ideal situation in terms of using the credit prices in the BCA. The habitat types provided by the bank and the economic conditions under which the bank is operating are specific to our Study Area. If this had not been the case, the BCA would probably rely on a benefits transfer where the credit prices from a bank with similar habitat outside the Study Area would be applied. This would not be as robust an application.

The estimated upperbound habitat values were based on Sheridan bank credit prices charged in May 2004. The specific prices were $50,000 for a wetlands credit[3] and $58,000 to $65,000 for a riparian credit (Landes, 2004a, pers. comm.). The $50,000 per credit for wetlands habitat had increased to $55,000 by August 2004 (Landes, 2004b, pers. comm.), indicating that the $50,000 used as the upperbound estimate in the BCA is not the full willingness to pay (i.e., value) for a habitat credit. This results in an undervaluing of the environmental benefits in this analysis. The conservation bank prices were in May 2004 dollars but were not adjusted to July 2004 dollars because they are not part of any standard bundle of consumer goods or construction materials or services. Applying the CPI or CCI would not be appropriate.

[3] A credit is assumed to be 1 acre in this analysis.

A brief, qualitative description of each habitat service is provided in Table 1. The habitat benefits associated with the structural flood control measures, nonstructural measures, and environmental enhancements are identified in Tables 2, 3, and 4, respectively. The range of habitat and recreation values is summarized in Table 5.

TABLE 1
Description of Environmental Benefits (Habitat Services and Recreation)
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Habitat Services | Description |
|---|---|
| **Water Quality** | |
| Reduced Sediment | Reduced sediment loads in streams improve habitat for many aquatic species, such as anadromous salmonids. |
| Nitrogen Removal | High nitrogen levels encourage algal blooms that can deplete oxygen to the detriment of aquatic species. Thus, removal of nitrogen from water improves habitat quality. |
| Temperature | Provision of cool water temperature improves survival and reproductive success of anadromous salmonids. |
| Increased Groundwater Recharge | Groundwater recharge increases the groundwater level and benefits water users through increased water supply and lower pumping costs. |
| Local Aquifer Recharge | Groundwater recharge increases the groundwater level and benefits water users through increased water supply and lower pumping costs. |
| Erosion Control/Soil Productivity | Erosion control benefits aquatic organisms by minimizing sediment input to streams. Soil productivity is improved by retention of topsoil. |
| Biodiversity | Creation and provision of native habitats such as wetland, riparian, and oak woodland habitats will contribute to increasing and maintaining native wildlife species. Habitat diversity provided by these habitats will contribute to maintaining a variety of wildlife species. |
| Specials-status Species Habitat | Provision of riparian, wetland, and oak woodland habitats will contribute to maintaining populations of special-status species. |
| Fall-run Chinook[a] | Improved habitat quality will enhance survival of fall-run chinook salmon. |
| **Endangered Species Benefit** | |
| Giant Garter Snake | Creation of wetlands habitat will increase habitat for giant garter snakes and may contribute to increasing the population size and distribution of this species. |
| Valley Elderberry Longhorn Beetle | Planting elderberry shrubs will increase habitat for the valley elderberry longhorn beetle and may contribute to increasing the population size and distribution of this species. |
| Winter-run Chinook[a] | Improved habitat quality will enhance survival of winter-run chinook salmon. |
| Steelhead[a] | Improved habitat quality will enhance survival of steelhead. |
| Ancillary Carbon Sequestration | Carbon dioxide is a greenhouse gas. By using carbon dioxide, plants remove this greenhouse gas from the atmosphere. |
| Improved Forage Production (Animal Units) | Increased plant biomass and nutrient content in pastures provides better-quality forage for livestock. |
| Downstream Water Quality Benefits[b] | Reduced nutrient and sediment input can improve aquatic habitat quality in downstream reaches. See Water Quality above. |
| Complements National Wildlife Refuges and Wildlife Areas | Creation of wetlands and riparian habitat adjacent to refuges enhances the habitat value of the refuges by providing a larger contiguous area of habitat. |
| **Recreation** | |
| Deer Hunting | Maintenance of open space and improving habitat quality can provide opportunities for deer hunting. |
| Duck/Waterfowl Hunting | Created wetlands can be managed to attract waterfowl and support hunting. |
| Fishing | Improved aquatic habitat quality could increase sport fish populations and enhance fishing. |
| Bird Watching | Wetlands and riparian habitat, in particular, will attract birds and become favorable for bird watching. |

TABLE 1
Description of Environmental Benefits (Habitat Services and Recreation)
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Habitat Services | Description |
|---|---|
| Wildlife Viewing | Increased habitat quality, quantity, and diversity could contribute to increased wildlife populations and diversity and be favorable for wildlife viewing. |
| Walking/Hiking | Maintenance of open space and creation of aesthetically pleasing natural areas will be attractive as walking/hiking areas. |

[a]Assumes the enhancement is adjacent to an anadromous stream.

[b]Reduced sediment delivery can improve anadromous fish habitat by improving spawning and rearing habitat quality, but reduced flood intensity can reduce habitat quality by affecting gravel recruitment and the health and persistence of riparian habitat over the long term.

TABLE 2
Structural Flood Control Measures: Habitat Services Encompassed in Estimated Habitat Values
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Habitat Services | South Fork Willow Detention Basin | Wilson Creek Detention Basin | Rice Field Spreading Basins | Stream Restoration – Upper Watershed | Stream Restoration – Valley | Ring Levee |
|---|---|---|---|---|---|---|
| **Water Quality** | | | | | | |
| Reduced Sediment | ✓ | ✓ | | ✓ | ✓ | |
| Nitrogen Removal | ✓ | ✓ | | | | |
| Temperature | | | | ✓ | ✓ | |
| Increased Groundwater Recharge | ✓ | ✓ | | | | |
| Local Aquifer Recharge | | ✓ | | | | |
| Erosion Control/Soil Productivity | | | | | | |
| Biodiversity | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Special-status Species Habitat | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Fall-run Chinook[a] | | | | | | |
| **Endangered Species Benefit** | | | | | | |
| Giant Garter Snake | | | ✓ | | ✓ | |
| Valley Elderberry Longhorn Beetle | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Winter-run Chinook[a] | | | | | | |
| Steelhead[a] | | | | | | |
| Ancillary Carbon Sequestration | | | | ✓ | ✓ | |
| Improved Forage Production (Animal Units) | ✓ | ✓ | | ✓ | | |
| Downstream Water Quality Benefits[b] | ✓ | ✓ | ✓ | ✓ | ✓ | |

[a]Assumes the enhancement is adjacent to an anadromous stream.

[b]Reduced sediment delivery can improve anadromous fish habitat by improving spawning and rearing habitat quality, but reduced flood intensity can reduce habitat quality by affecting gravel recruitment and the health and persistence of riparian habitat over the long term.

TABLE 3
Nonstructural Flood Control Measures: Habitat Services Encompassed in Estimated Habitat Values
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Habitat Services | Rangeland Management | Reforestation | Floodplain Management |
|---|---|---|---|
| **Water Quality** | | | |
| Reduced Sediment | ✓ | ✓ | |
| Nitrogen Removal | | | |
| Temperature | | | |
| Increased Groundwater Recharge | ✓ | | |
| Local Aquifer Recharge | | | |
| Erosion Control/Soil Productivity | ✓ | ✓ | |
| Biodiversity | ✓ | ✓ | |
| Special-status Species Habitat | ✓ | ✓ | |
| Fall-run Chinook[a] | | | |
| **Endangered Species Benefit** | | | |
| Giant Garter Snake | | | |
| Valley Elderberry Longhorn Beetle | | | |
| Winter-run Chinook[a] | | | |
| Steelhead[a] | | | |
| Ancillary Carbon Sequestration | ✓ | ✓ | |
| Improved Forage Production (Animal Units) | ✓ | | |
| Downstream Water Quality Benefits[b] | ✓ | ✓ | |

[a]Assumes the enhancement is adjacent to an anadromous stream.

[b]Reduced sediment delivery can improve anadromous fish habitat by improving spawning and rearing habitat quality, but reduced flood intensity can reduce habitat quality by affecting gravel recruitment and the health and persistence of riparian habitat over the long term.

TABLE 4
Environmental Enhancements: Habitat Services Encompassed in Estimated Habitat Values
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Habitat Services | Combined Wetland and Riparian Habitat |
|---|---|
| **Water Quality** | |
| Reduced Sediment | ✓ |
| Nitrogen Removal | ✓ |
| Temperature | ✓ |
| Increased Groundwater Recharge | |
| Local Aquifer Recharge | |
| Erosion Control/Soil Productivity | ✓ |
| Biodiversity | ✓ |
| Special-status Species Habitat | ✓ |
| Fall-run Chinook[a] | ✓ |
| Endangered Species Benefit | |
| Giant Garter Snake | ✓ |
| Valley Elderberry Longhorn Beetle | ✓ |
| Winter-run Chinook[a] | ✓ |
| Steelhead[a] | ✓ |
| Ancillary Carbon Sequestration | ✓ |
| Improved Forage Production (Animal Units) | |
| Downstream Water Quality Benefits[b] | ✓ |
| Complements National Wildlife Refuges and Wildlife Areas | ✓ |

[a]Assumes the enhancement is adjacent to an anadromous stream.

[b]Reduced sediment delivery can improve anadromous fish habitat by improving spawning and rearing habitat quality, but reduced flood intensity can reduce habitat quality by affecting gravel recruitment and the health and persistence of riparian habitat over the long term.

TABLE 5
Range of Habitat and Recreation Values Summarized by Alternative and Flood Control Measure
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| | Environmental Benefits (in July 2004 $) | | | | | |
|---|---|---|---|---|---|---|
| | Habitat($/acre) | | | Recreation ($/visitor day) | | |
| **Flood Control Measure** | **Lower Bound[a]** | **Average[c]** | **Upper Bound[b]** | **Lower Bound[d]** | **Average[c]** | **Upper Bound[d]** |
| **South Fork Willow Creek Detention Basin** | | | | | | |
| Habitat | 8,555 | 29,278 | 50,000 | | | |
| Wildlife Viewing | | | | 3 | 37 | 195 |
| Bird Watching | | | | na | 33 | na |
| Walking/Hiking | | | | 2 | 44 | 264 |
| **Wilson Creek Detention Basin** | | | | | | |
| Habitat | 8,097 | 29,049 | 50,000 | | | |
| Wildlife Viewing | | | | 3 | 37 | 195 |
| Bird Watching | | | | na | 33 | na |
| Walking/Hiking | | | | 2 | 44 | 264 |
| **Rice Field Spreading Basins** | | | | | | |
| Habitat | 11,751 | 16,032 | 20,313 | | | |
| Recreation | | | | 0 | 0 | 0 |
| **Stream Restoration – Upper Watershed** | | | | | | |
| Habitat | 74,109 | 79,814 | 85,519 | | | |
| Recreation | | | | 0 | 0 | 0 |
| **Stream Restoration – Valley Floor** | | | | | | |
| Habitat | 69,978 | 76,362 | 82,745 | | | |
| Recreation | | | | 0 | 0 | 0 |
| **Ring Levee** | | | | | | |
| Habitat | 0 | 0 | 0 | | | |
| Recreation | | | | 0 | 0 | 0 |
| **Rangeland Management** | | | | | | |
| Habitat | 170 | 374 | 577 | | | |
| Recreation | | | | 0 | 0 | 0 |

TABLE 5
Range of Habitat and Recreation Values Summarized by Alternative and Flood Control Measure
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| | Environmental Benefits (in July 2004 $) | | | | | |
|---|---|---|---|---|---|---|
| | Habitat($/acre) | | | Recreation ($/visitor day) | | |
| **Flood Control Measure** | **Lower Bound[a]** | **Average[c]** | **Upper Bound[b]** | **Lower Bound[d]** | **Average[c]** | **Upper Bound[d]** |
| **Reforestation** | | | | | | |
| Habitat | 13,657 | 20,239 | 26,821 | | | |
| Recreation | | | | 0 | 0 | 0 |
| **Floodplain Management** | | | | | | |
| Habitat | 0 | 0 | 0 | | | |
| Recreation | | | | 0 | 0 | 0 |
| **Environmental Enhancements** | | | | | | |
| Habitat | 9,797 | 29,899 | 50,000 | | | |
| Duck Hunting | | | | 3 | 38 | 173 |
| Wildlife Viewing | | | | 3 | 37 | 195 |
| Walking/Hiking | | | | 2 | 44 | 264 |

[a]The Natomas Basin wetlands project costs were assumed to be representative of costs to create the habitat associated with the detention basins, the rice field spreading basins, and environmental enhancements. Thus, they were used to estimate habitat benefit. The benefit estimates for the stream restorations (Upper Watershed and Valley), rangeland management, and reforestation measures are assumed equal to the costs of creating the habitat for those measures. The ring levee and floodplain management measures are assumed not to have any habitat benefits.

[b]The upperbound estimates of habitat benefits for the detention basins, rice field spreading basins, and environmental enhancements are based on the Wildlands, Inc., Sheridan conservation bank credit price for wetlands. The benefit estimates for the stream restorations (Upper Watershed and Valley), rangeland management, and reforestation measures are based on the cost to create the habitat. The ring levee and floodplain management measures are assumed not to have any habitat benefits.

[c]The average estimates are the average of the lower and upper bounds.

[d]The lower- and upperbound estimates of recreation benefits are from the recreation and natural resource economics literature (Rosenberger and Loomis, 2001).

Notes:

na = not available
shaded = not applicable

## Recreation Benefits

Recreation benefits were quantified in monetary terms because data were available. A range of recreation values measured in dollars per visitor day was gleaned from the recreation economics literature (Rosenberger and Loomis, 2001) for each activity. Recreation benefits are described qualitatively in Table 1, and they are identified for the structural flood control measures, nonstructural measures, and environmental enhancements in Tables 6, 7, and 8, respectively.

TABLE 6
Structural Flood Control Measures: Recreation Benefits
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Recreation Activities | South Fork Willow Creek Detention Basin | Wilson Creek Detention Basin | Rice Field Spreading Basins | Stream Restoration – Upper Watershed | Stream Restoration – Valley | Ring Levee |
|---|---|---|---|---|---|---|
| Deer Hunting | ✓ | ✓ | | | | |
| Duck/Waterfowl Hunting | ✓ | ✓ | | | | |
| Fishing | | | | | | |
| Bird Watching | ✓ | ✓ | | | | |
| Wildlife Viewing | ✓ | ✓ | | | | |
| Walking/Hiking | ✓ | ✓ | | | | |

TABLE 7
Nonstructural Flood Control Measures: Recreation Benefits
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Recreation Activities | Rangeland Management | Reforestation | Floodplain Management |
|---|---|---|---|
| Deer Hunting | ✓ | ✓ | |
| Duck/Waterfowl Hunting | | | |
| Fishing | | | |
| Bird Watching | ✓ | ✓ | |
| Wildlife Viewing | ✓ | ✓ | |
| Walking/Hiking | ✓ | ✓ | |

TABLE 8
Environmental Enhancements: Recreation Benefits
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Recreation Activities | Combined Wetland and Riparian Habitat |
|---|---|
| Deer Hunting | |
| Duck/Waterfowl Hunting | ✓ |
| Fishing | ✓ |
| Bird Watching | ✓ |
| Wildlife Viewing | ✓ |
| Walking/Hiking | ✓ |

### Avoided Flood Damage Benefits

The avoided flood damages were estimated using the U.S. Army Corps of Engineer's Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA, or FDA) program. The avoided flood damages were estimated for different combinations of the proposed flood control measures and for individual measures as shown in Table 9. Assumptions made to estimate the avoided flood damages are discussed in *Floodplain Inundation and Hydraulics Analysis of Alternatives for Flood Damage Assessment* (Appendix A to the Feasibility Study). The avoided flood damages estimated by FDA for each alternative were expressed as annualized expected damage reduction over the life of the project at a discount rate of 5 5/8 percent. This annualized value was then converted to a present value and added directly to the present value of the habitat and recreation benefits for estimated total benefits.

TABLE 9
Avoided Flood Damage Benefits
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Alternative | Annualized Avoided Flood Damages (January 2004 $) | Present Value of Avoided Flood Damages (July 2004 $) |
|---|---|---|
| Structural (without ring levee) | 1,943,075 | 32,304,673 |
| Nonstructural (without floodplain management) | 202,556 | 3,367,602 |
| Combined (without ring levee and floodplain management) | 2,102,823 | 34,960,565 |
| Detention Basins | 1,814,650 | 30,169,544 |
| Ring Levee | 2,571,625 | 42,754,653 |
| Floodplain Management | 1,716,505 | 28,537,819 |
| Environmental Enhancements | Not estimated | Not estimated |

## Costs

The true costs, (i.e., full social costs) of a project are measured by the direct costs of the project, such as construction, land, and O&M costs, plus any impacts to society. Examples include downstream third-party impacts and associated costs that are required to achieve the benefits of the proposed project but not accounted for in cost estimates. The cost estimates used in this BCA attempt to capture as much of the true costs of a flood control measure as possible. When there are third-party impacts or associated costs that could not be quantified at the time of the analysis, they are identified qualitatively.

Construction and O&M cost estimates for the flood control measures came from two primary sources: the Natomas Basin projects (Wildlands, Inc, 2003) and engineering cost estimates (CH2M HILL, 2003). A range was developed for capital and O&M costs for each measure where possible. The capital and O&M cost variations for wetland and riparian habitat for the detention basins, rice field spreading basins, and the environmental enhancements were based on the Natomas Basin projects with similar habitat characteristics. Variation for the structural flood control measures (except the stream restoration measures) was based on a 10 percent difference above and below capital and O&M estimates developed for the measures. Specific cost and O&M ranges were developed for the two stream restoration measures, rangeland revegetation and reforestation nonstructural measures, and the floodplain management measures.

The cost of any land acquisitions required for the flood control measures were estimated with values from the American Society of Farm Managers and Rural Appraisers (ASFMRA) or easement prices. The ASFMRA 2003 land survey values were used, but not adjusted to July 2004 dollars. The CCI and CPI indices do not contain land prices as components; therefore, it would not be appropriate to use either to estimate the projected increase of land values. Estimates of easement prices were provided by the California Department of Conservation (Bryant, 2004, pers. comm.) and reported in June 2003 dollars. Easement prices were not adjusted to July 2004 dollars because they represent an average for all agricultural lands and are affected by many factors in addition to consumer behavior. Examples include the activities allowed after the purchase of an easement, the type of land use at the time of the easement purchase, and the objectives of the easement program. The range of costs used in this analysis is summarized in Table 10.

# Assumptions Regarding Structural Flood Control Measures

## South Fork Willow Creek Detention Basin

### Benefits

It was assumed that 16 acres of combined wetland and riparian habitat would be created with the South Fork Willow Creek detention basin. The lowerbound estimated value of this habitat was based on the Natomas Basin projects, and the upperbound estimates were based on conservation bank credit prices for wetlands. The conservation bank wetlands value was used for all of the combined acres because the detention basin habitat would be predominantly wetlands and using the wetlands value is conservative, tending to underestimate benefits. Wetlands credit[4] prices are $50,000 per acre, whereas the riparian habitat credit price ranges from $58,000 to $65,000.

The District owns the land on which the site of the detention basin is proposed, and it was assumed this land would be accessible for recreation activities. Some recreation opportunities would likely be in the form of docent-led tours. The docents would be volunteers with knowledge of the local flora and fauna and operation of the detention basin. Tours would allow access in a controlled fashion to limit disturbance of the wetland, riparian, and surrounding habitat and provide added value through interpretation by the docent. It was assumed there would be the following tours annually:

- 15 wildlife-viewing tours of 25 people each totaling 375 wildlife-viewing visitor days
- 15 bird-watching tours of 25 people each, totaling 375 bird-watching visitor days
- 15 hiking/walking tours of 25 people each totaling 375 walking/hiking visitor days.

[4] Throughout this BCA, a habitat credit is assumed equal to 1 acre of habitat.

TABLE 10
Range of Estimated Costs (in July 2004 $)
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Flood Control Measure | Habitat Creation ($/acre) | | | Capital Construction | | | Land Purchase ($/acre) | | | Land Easement ($/acre) | O&M Habitat ($/acre) | | | O&M Capital ($/year) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lower Bound | Average | Upper Bound | Lower Bound | Average | Upper Bound | Lower Bound | Average | Upper Bound | | Lower Bound | Average | Upper Bound | Lower Bound | Average | Upper Bound |
| **South Fork Willow Creek Detention Basin** | | | | | | | | | | | | | | | | |
| Habitat | 3,726[a] | 5,642[a] | 7,558[a] | | | | | | | | 245 | 345 | 446 | | | |
| Capital | | | | 11,241,574 | na | 13,739,701 | | | | | | | | na | 292,105 | na |
| Land | | | | | | | | $19,708 | | | | | | | | |
| **Wilson Creek Detention Basin** | | | | | | | | | | | | | | | | |
| Habitat | 3,726[a] | 5,642[a] | 7,558[a] | | | | | | | | 245 | 345 | 446 | | | |
| Capital | | | | 10,332,969 | na | 12,629,184 | | | | | | | | na | 178,329 | na |
| Land | | | | | | | 2,500 | 5,250 | 8,000 | 0 (n) | | | | | | |
| **Rice Field Spreading Basins** | | | | | | | | | | | | | | | | |
| Habitat | 6,294(c) | 8,906(c) | 11,517(c) | | | | | | | | 245 | 345 | 446 | | | |
| Capital | | | | 8,326,305 | na | 10,176,595 | | | | | | | | na | 187,475 | na |
| Land | | | | | | | 0 | 0 | 0 | 1,400 (b) | | | | | | |
| **Stream Restoration – Upper Watershed** | | | | | | | | | | | | | | | | |
| Habitat | na | 77,300 (d) | na | | | | | | | | 3,249 (l) | 3,314 (l) | 3,379 (l) | | | |
| Capital | | | | na | 13,604,762 | na | | | | | | | | 0 | 0 | 0 |
| Land | | | | | | | 0 | 0 | 0 | 0 | | | | | | |
| **Stream Restoration – Valley Floor** | | | | | | | | | | | | | | | | |
| Habitat | na | 45,246 (m) | na | | | | | | | | 2,045 (l) | 2,083 (l) | 2,122 (l) | | | |
| Capital | | | | na | 1,1125,627 (k) | na | | | | | | | | 0 | 0 | 0 |
| Land | | | | | | | 0 | 0 | 0 | 0 | | | | | | |
| **Ring Levee** | | | | | | | | | | | | | | | | |
| Habitat | 0 | 0 | 0 | | | | | | | | 0 | 0 | 0 | | | |
| Capital | | | | 1,822,930 | na | 2,228,026 | | | | | | | | na | 104,478 | na |
| Land | | | | | | | 8,000 | 11,500 | 15,000 | 0 | | | | | | |
| **Rangeland Management** | | | | | | | | | | | | | | | | |
| Habitat | 98 | 293 | 488 | | | | | | | | 5/5 (i) | 8/5 (i) | 12/5 (i) | | | |
| Capital | | | | (h) | (h) | (h) | | | | | | | | 0 | 0 | 0 |
| Land | | | | | | | 0 | 0 | 0 | 0 | | | | | | |

TABLE 10
Range of Estimated Costs (in July 2004 $)
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Flood Control Measure | Habitat Creation ($/acre) | | | Capital Construction | | | Land Purchase ($/acre) | | | Land Easement ($/acre) | O&M Habitat ($/acre) | | | O&M Capital ($/year) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lower Bound | Average | Upper Bound | Lower Bound | Average | Upper Bound | Lower Bound | Average | Upper Bound | | Lower Bound | Average | Upper Bound | Lower Bound | Average | Upper Bound |
| **Reforestation** | | | | | | | | | | | | | | | | |
| Habitat | 3,410 | 7,014 | 10,619 | | | | | | | | 3/0 (i) | 4/0 (i) | 5/0 (i) | | | |
| Capital | | | | (j) | (j) | (j) | | | | | | | | 0 | 0 | |
| Land | | | | | | | 0 | 0 | 0 | 0 | | | | | | |
| **Floodplain Management** | | | | | | | | | | | | | | | | |
| Habitat | 0 | 0 | 0 | | | | | | | | 0 | 0 | 0 | | | |
| Capital | | | | | 4,484,008 | | | | | | | | | 0 | 0 | 0 |
| Land | | | | | | | 0 | 0 | 0 | 0 | | | | | | |
| **Environmental Enhancements** | | | | | | | | | | | | | | | | |
| Habitat | 3,726 (e) | 5,642 (e) | 7,558 (e) | | | | | | | | 245 (e) | 345 (e) | 446 (e) | | | |
| Capital | | | | (f) | (f) | (f) | | | | | | | | (f) | (f) | (f) |
| Land | | | | | | | 2,000 (g) | 2,800 (g) | 3,600 (g) | 1,400 (g) | | | | | | |

Notes:

na = not available

shaded = not applicable

(a) The habitat creation costs associated with the South Fork Willow Creek and Wilson Creek detention basins are approximately 1% of construction costs and, therefore, are assumed to be a part of the capital construction costs. Costs were based on Natomas Basin projects.

(b) Rice field spreading basin infrastructure and habitat requires relatively little land. It is assumed easements are appropriate.

(c) The habitat creation costs associated with the rice field spreading basins are approximately 1% of construction costs and, therefore, are assumed to be a part of the construction costs.

(d) The imputed willingness to pay method is applied with the measure’s cost estimate; and thus, the per-acre habitat creation costs are equal to the estimated construction costs divided by the number of habitat acres.

(e) Habitat creation costs and O&M costs are based on the Natomas Basin wetlands project’s estimated and actual creation costs.

(f) It is assumed that capital construction and O&M are included in the habitat creation costs.

(g) Assumes rice fields are purchased or easements are sold to acquire land to create the wetland and riparian habitats.

(h) No capital costs are included because the management effort is assumed to start with existing rangeland that has the necessary infrastructure (e.g., fencing and water sources).

(i) The O&M per acre during establishment/theO&M per acre after establishment.

(j) Assumes no capital construction is required for reforestation. Cost of seeds and seedlings is included in habitat creation costs.

(k) Capital construction costs are associated with the bridge extensions, traffic control, and environmental and design costs.

(l) Represents annual costs for periodic monitoring and repair and enhancement of the restoration. The O&M also includes a redesign and rebuild cost in the 25th year of the project that is 10% of the design costs. It is assumed that in the 50-year life of the project, there is one hydrologic event that alters the restoration significantly, requiring redesign of the restoration.

(m) Represents per-acre cost of creating habitat only (excludes capital cost of bridges).

(n) Assumes land will have to be purchased because the current land use is an almond orchard. The inundation from the detention basin would severely hamper the productivity of the orchard.

The benefits estimate does not take into consideration population growth. As population grows over the life of the project, it would be expected that the visitor days would increase for recreation activities. The effects of population growth were not included because data were not readily available to define the geographic area from which people would come to recreate. The area would need to be defined to analyze impacts from population growth.

Other potential benefits not included in this analysis are recreational benefits from hunting, revenues from entrance fees or donations, and time volunteered by the docents. Omitting these potential benefits tends to underestimate benefits.

### Costs

The costs for the South Fork Willow Creek detention basin included the detention basin's construction costs and O&M costs for the habitat and the embankment and related structures. Costs to construct the seasonal wetlands were assumed to be accounted for in construction cost estimate because they are small (approximately 1 percent) relative to building the detention basin. Costs to provide basic visitor amenities such as signage, a gravel parking area, and portable lavatories were assumed in the construction contingency and O&M estimates.

Land at the site of the South Fork Willow Creek detention basin is owned by the District (purchased in January of 2004), and the current land use is grazing. Any land used for the detention basin, particularly for the embankment and the seasonal wetlands, would be unavailable for another use and was assumed to be an opportunity cost. Occasional inundation from the Basin does not impact grazing activities on the remaining land. The opportunity cost was estimated by prorating the proportion of the land needed for the detention basin, disturbed areas, and the seasonal wetlands. The per-acre cost is approximately $758. The embankment, impact areas, and seasonal wetlands account for 26 acres; and therefore, $19,708 was the estimated opportunity costs.

## Wilson Creek Detention Basin

### Benefits

The Wilson Creek detention basin would include 17 acres of combined wetland and riparian habitat. The assumptions for the habitat and recreation benefits estimates for the Wilson Creek detention basin are the same as those for the South Fork Willow Creek detention basin.

Other potential benefits not included in the analysis are also the same.

### Costs

Habitat, capital, and O&M cost assumptions for the Wilson Creek detention basin are similar to those for South Fork Willow Creek detention basin.

A land purchase would likely be needed for the Wilson Creek detention basin and areas that would be inundated up to the 100-year storm event. Although the purchase of easements would represent a lower land cost, they are not likely to be applicable in this case. The current land use is almond orchards that probably could not withstand the periodic inundation created by the detention basins. It was assumed that 326 acres would be needed, which are twice the inundated acres in a 100-year flood (163 acres). The additional land would allow for buffers around the seasonal wetlands, recreation activities, and visitor amenities such as parking. The estimated range of almond orchard land prices is $2,500 to $8,000 per acre (ASFMRA, 2003).

# Rice Field Spreading Basins

## Benefits

Habitat created around the rice field spreading basins and along the diversion canals would be just over 9 acres of riparian. The value of this habitat was estimated by imputing willingness to pay, using the creation and O&M cost estimates for two sites in the Natomas Basin – Brennan and Souza-Natomas. These sites are predominantly upland habitat (Wildlands, Inc., 2003). The construction cost estimate for this measure is for the infrastructure needed to create the spreading basins. Therefore, the construction cost estimate would not represent the costs for creating riparian habitat along the basins and diversion canals.

No recreation benefits are associated with this measure.

### Costs

The construction and O&M costs of this measure are based on the construction cost estimate. The estimated cost of creating the riparian habitat is small (approximately 1 percent) compared to the cost of creating the embankments for the spreading basins and, therefore, is assumed part of the construction contingency. Easements are likely to meet the land acquisition needs for this measure because a relatively small amount of land around the perimeter of the rice fields and along the diversion and return channels would be required for each potential spreading basin. The cost of the easement was assumed to be $1,400 per acre.

# Stream Restoration – Upper Watershed

## Benefits

Because similar restoration projects in the Study Area were not available to develop an imputed value for benefits, it was assumed that the cost of the stream restoration measure itself is equal to the lower- and upperbound benefits for this measure. The lower and upper bounds vary by the estimated O&M costs. The cost estimate for this measure was entirely attributable to the cost of channel reshaping, bank stabilization, and creating and maintaining the approximately 176 acres of riparian habitat that would be enhanced under this measure. By assuming that the cost estimated represents the least-cost alternative, the present value of benefits equaled the present value of the costs.

Conservation bank credit prices for riparian habitat were not applied to this measure because the riparian habit would not be of the quality of a conservation bank. The primary reasons for this are that existing land uses such as grazing and agricultural activities would continue, and the restoration would be monitored and maintained less frequently than would be required for a bank. Monitoring is assumed to occur at most once very 5 years and as infrequently as once very 10 years. While the restoration is designed to withstand future hydrologic conditions, local conditions may degrade the habitat between monitoring periods.

It was assumed there would be no recreation benefits associated with this measure. The stream restoration would provide bank protection and riparian buffer strips for 50 percent of the upland portions of North Fork Willow, South Fork Willow, and Wilson Creeks. This is not a large or contiguous area that would support additional recreation.

Not included in the benefits estimate is the potential value of the learning opportunity from the adaptive management process that could be applied to monitoring the restoration.

### Costs

Costs for this measure were based on the cost estimates for bank stabilization, habitat creation, monitoring, maintenance, and adaptive management. It was assumed that monitoring and repair and enhancement costs are needed periodically, ranging from 5 to 10 years, to maintain the integrity of the stream restoration. Monitoring costs were assumed to be the labor costs for a professional geomorphologist and two field technicians. Repair and enhancement costs were assumed to be 5 percent of initial construction costs. It was assumed that once in the 50-year life of this project a greater than 50-year storm event would overwhelm the capacity of the project and result in the need for redesigning and reconstructing sections of the restoration. The event was placed in the 25th year of the project's life to avoid over- or underestimating the effect of the event on the stream of discounted costs. The cost for redesign and reconstruction was assumed to be 10 percent of the original design cost.

It was assumed that land acquisition and easements would not be needed. Existing land uses would continue, there would be no limited access, and there would be no required maintenance from the landowner.

## Assumptions Stream Restoration – Valley Floor

### Benefits

This measure consists of two parts. The first is restoring the channel sinuosity and enhancing streambanks of Willow and Wilson Creeks on the Valley Floor, and the second is extending the bridges over the creeks after the sinuosity changes. Because similar restoration projects in the Study Area were not available to develop an imputed value for benefits, it was assumed that the cost of the Valley stream restoration measure itself is equal to the lower- and upperbound benefits for this measure. The lower and upper bounds vary by the estimated O&M costs. Only the costs associated with stream restoration (increasing sinuosity and planting riparian vegetation on approximately 226 acres) and subsequent monitoring, maintenance, and adaptive management were used to impute the willingness to pay for habitat benefits. The costs included were the construction costs, labor costs of a professional geomorphologist and two field technicians to conduct monitoring activities, repair and enhancement costs, and a one-time redesign and reconstruction costs resulting from a greater than 50-year storm event. The redesign and reconstruction was placed in the

25th year of the project's life, and the cost for redesign and reconstruction was assumed to be 10 percent of the original design cost.

No recreation benefits were associated with this measure. The increased stream channel sinuosity and enhanced streambank vegetation would not likely increase recreation opportunities above existing conditions.

Not included in the benefits estimate is the value of the adaptive management learning opportunity.

### Costs

The construction costs for this measure included those for stream restoration and the bridge extensions. The O&M costs were for the restoration only. It was assumed the bridge extensions would not create any additional O&M costs. It was assumed that streambank and habitat monitoring and repair and enhancement costs would be needed every 5 to 10 years to maintain the integrity of the stream restoration. Monitoring costs were assumed to be the labor costs of a professional geomorphologist and two field technicians. Repair and enhancement costs were assumed to be 5 percent of initial construction costs. It was assumed that once in the 50-year life of this project a greater than 50-year storm event would overwhelm the capacity of the project and result in the need for redesigning and reconstructing a section of the restoration. The event was placed in the 25th year of the project's life to avoid over- or underestimating the effect of the event on the stream of discounted costs. The cost for redesign and reconstruction was assumed to be 10 percent of the original design cost.

It was assumed that land acquisition and easements would not be needed. Existing land uses would continue, there would be no limited access, and there would be no required maintenance from the landowner.

## Ring Levee

### Benefits

There are avoided flood damage benefits associated with the ring levee, but no habitat or recreation benefits.

### Costs

Construction and O&M costs were based on the cost estimate developed for this measure. Approximately 21 acres of land would be needed to construct the ring levee. The current land use at the site of the proposed ring levee was assumed to be rural residential because the site would be near existing development. The purchase of land was assumed the only feasible land acquisition method because the ring levee would be a permanent structure that would be owned and maintained by the District and/or a state or federal agency. The per-acre cost of rural residential land is assumed to be $8,000 to $15,000 (ASFMRA, 2003).

Although the ring levee would protect urban areas in the northeastern portion of the City of Willows, it could create flood-related impacts downstream. The downstream impacts of a ring levee were not hydrologically modeled, but inspection of the flood inundation maps indicate the impacts would be minimal compared to the overall size of the flooded area (CH2M HILL, 2003). The costs of downstream impacts were not included in this BCA because they have not been identified. This potentially underestimates the costs associated with the ring levee.

# Assumptions Regarding Nonstructural Flood Control Measures

## Rangeland Management

### Benefits

Approximately 40,000 acres of rangeland were proposed for revegetation with native grasses. The grasslands habitat that would be created would allow continued grazing, although it may be under different grazing management plans to sustain the native grass community. As a result, the grasslands would not be of the same quality as that maintained by conservation banks; and therefore, conservation bank credit prices cannot be applied to this measure. Because similar restoration projects in the Study Area were not available to develop an imputed value for benefits, it was assumed that the cost of the rangeland management measure itself is equal to the lower- and upperbound benefits for this measure. The lower and upper bounds vary by estimated capital and O&M costs. This results in the present value of the benefits equaling the present value of the costs.

No recreation benefits are associated with this measure.

A potential benefit is improved forage for grazing. However, it is difficult to determine the extent of the benefit without having specific information about each restoration site and a grazing management plan.

### Costs

The costs of this alternative included the labor and materials needed for site preparation, planting native grasses, initial higher intensity O&M during the 3-year establishment period, and less intensive O&M during the remainder of the project life.

It was assumed land and grazing easements purchases would not be needed because the revegetation would not preclude grazing activities, although grazing would probably need to occur in a manner that maintains the native grass community. Landowner conservation agreements, which are short-term contractual agreements, could be used to define any grazing and maintenance requirements during the establishment period. These agreements are over shorter time frames than easements and provide the landowner more flexibility to participate in other conservation programs and enhance their chances of being accepted into an easement program in the future because of higher quality rangeland (Gustafson, 2004, pers. comm.). The landowner conservation agreements would require administrative costs to create, but are not quantified in this analysis because the number of agreements needed is not known.

Because the rangeland slated for restoration is established rangeland, it was assumed that fencing already exists and the management measures would not significantly increase fencing costs. Other potential costs not included in this analysis are water development.

Without knowing specific site and land use information, it is not apparent if water development costs are appropriate.

The costs of this measure might be underestimated because the administrative costs of landowner conservation agreement, fencing, and water development costs were not included in this analysis.

## Reforestation

### Benefits

This measure proposes to enhance 4,600 acres of native oak woodland. Like the rangeland management flood control measure, the woodland acreage would not be comparable to conservation bank habitat. Because similar restoration projects in the Study Area were not available to develop an imputed value for benefits, it was assumed that the cost of the reforestation measure itself is equal to the lower- and upperbound benefits for this measure. The lower and upper bounds vary by estimated capital and O&M costs. The value of habitat benefits of this flood control measure were estimated by imputing willingness to pay based on the measure's cost estimate under the assumption that the habitat benefits are equal to the cost of creating and maintaining the habitat. This results in the present value of the benefits equaling the present value of the costs.

Recreation benefits were not estimated for this measure. However, it is likely that with additional forest canopy and improved grass and potentially acorn production, wildlife populations could increase, which would improve opportunities for hunting, bird watching, and wildlife viewing. In addition, hiking/walking could be enhanced because of more pleasing woodland aesthetics.

### Costs

The costs of this alternative included site preparation, planting of acorns and/or oak saplings, and initial O&M during the 3- to 5-year establishment period. No O&M costs are assumed for this measure after the trees are established.

It was assumed that land and easements would not be purchased for this measure. The establishment period is 3 to 5 years, and a land conservation agreement could be created to define landowner activity and maintenance responsibilities during that period. Landowner conservation agreements are short-term contractual agreements that allow an establishment period to be set, but not permanently change land uses giving the landowner's flexibility. Administrative costs are associated with the landowner conservation agreements, but they were not included in this analysis because it is not known how many agreements would be needed. This might result in the costs being underestimated.

## Floodplain Management

### Benefits

Protecting residential, commercial, and industrial structures from flood damage may be accomplished in several ways including raising them above a certain flood depth. Only residential structures were assumed to be raised in this BCA. Cost estimates for protecting commercial and industrial structures were not readily available. There are avoided flood damage benefits associated with elevating structures, but no habitat or recreation benefits were assumed.

Additional benefits not quantified in this analysis include increased peace of mind and well-being for residents in the floodplain knowing that their homes and possessions are under a higher level of flood protection. This can increase the quality of life. If a structure is elevated according to FEMA National Flood Insurance standards, flood insurance is no longer required. This would represent a benefit in the form of an avoided cost for those homeowners choosing to forego purchasing flood insurance.

### Costs

Factors that determine the cost to elevate a structure are the type of construction, type of foundation, size of the structure's footprint, and the height to which it needs to be raised (FEMA, 1998). Frame construction and elevated foundations are less expensive to raise than masonry construction and slab foundations. The higher the structure needs to be raised and the larger the footprint, the more expensive. For the BCA, it was assumed that the structures are frame construction with raised foundations and would be raised to the height of the 100-year flood plus 1 foot of freeboard. This ranges from 1 foot to 7 feet in the impact areas.

It was assumed that only 67 percent of the residential structures in the Study Area would be raised. Not all home owners will want to elevate their homes for various reasons, such as cost and preferences. Sixty-seven percent of the residential structures in each impact area were randomly chosen. If the square footage of the structure was less than or equal to 3,000, then the structure was assumed to be one story, and the footprint equaled the square footage. If the structure was greater than 3,000 square feet, it was assumed it was a two-story building and the footprint equaled half the square footage.

Relocation costs were included in this analysis. While a structure is being raised, its residents cannot occupy it. The expected length of time a structure is uninhabitable is 90 days (FEMA, 1998). Relocation costs for each structure raised were assumed to be the median contract rental rate in Willows ($400 in July 2004 adjusted from the 2000 Census) for 3 months.

A similar project of raising structures to avoid flood damage is currently underway in Tehama County. This project experienced unexpected costs because older structures needed additional repairs to be brought up to current building standards (Cowdin, 2004, pers. comm.). These costs were not included in the FEMA estimates. If this were also the case in Willows, then the costs in this analysis could be underestimated.

## Assumptions Regarding Environmental Enhancements

### Benefits

The environmental enhancements assumed in the BCA were approximately 3,000 acres of combined wetland and riparian habitats. The primary benefits from the proposed enhancement would be habitat and the associated ecological services. For the BCA it was assumed 75 percent (2,250 acres) would be wetlands and 25 percent (750 acres) would be riparian. It was assumed that the habitat associated with environmental enhancements would be maintained to be comparable to the habitat at a conservation bank and that the acreages would be accessible for recreation. To be conservative, the conservation bank wetlands value was used for all of the combined wetland and riparian acres because the enhancements would be predominantly wetlands and the wetlands value somewhat underestimates the habitat benefit. Wetlands credit prices are $50,000 per acre, and the riparian habitat credit price ranges from $58,000 to $65,000 (Landes, 2004a, pers. comm.).

Estimates of visitor days for recreation activities were based on extrapolations from the Colusa National Wildlife Refuge (Colusa NWR). The Colusa NWR provides similar consumptive (e.g., hunting) and nonconsumptive (e.g., wildlife viewing) recreation activities that would be considered for the proposed enhancements. The proportion of visitor days assumed for each activity would be scaled by the 4,956-acre Colusa NWR, resulting in a scaling factor of 0.6 (3,000/4,956 = 0.6) (USFWS). The recreation benefit was not included in this analysis because it is uncertain which activities would be compatible with the environmental enhancements. The assumed benefit would increase if recreation benefits were included.

### Costs

The construction costs for the environmental enhancements were based on the range of costs reported for the Natomas Basin wetland projects, which include design and permitting costs (Wildlands, 2003). A 25 percent contingency was applied to these estimates for compatibility with the cost estimates for the other flood control measures. The O&M cost estimates were also based on the range reported for the Natomas Basin projects. No contingency was placed on the O&M estimates.

The land that would be needed for the environmental enhancements was assumed to be rice lands that would be purchased. The most expensive option would be to purchase all the land for the enhancements. The assumed costs would be lower if easements were purchased for a portion of the land.

## Results

Six benefit and cost scenarios were formulated using low, average, and high benefits paired with low costs and high costs. The low benefits and high cost scenario is considered the most conservative estimate of the benefit/cost ratio. Likewise, the high benefits and low cost ratio would be the least conservative. All benefits and costs are expressed in July 2004 dollars, and streams of benefits and costs were discounted by the fiscal year 2004 federal discount rate of 5 5/8 percent. Table 11 summarizes the ratios for combinations of flood control measures and individual measures examined in this BCA.

A sensitivity analysis was conducted on the BCA by varying the discount rate of 5 5/8 to 2 5/8 percent and 8 5/8 percent. The sensitivity analysis shows results that are consistent with a priori expectations that the benefit/cost ratio would increase with a lower discount rate and decrease with a higher discount rate. This pattern is expected because for each flood control measure, capital costs occur as one-time, upfront costs and, thus, were not subject to discounting, while the benefits and O&M costs accrue throughout the life of the project.

TABLE 11
Summary of Benefit Cost Ratios
*Benefit/Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study*

| Alternative/Measure | High Cost Scenario | | | | | | | | | Low Cost Scenario | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low Benefits | | | Average Benefits | | | High Benefits | | | Low Benefits | | | Average Benefits | | | High Benefits | | |
| | **2 5/8%** | **5 5/8%** | **8 5/8%** | **2 5/8%** | **5 5/8%** | **8 5/8%** | **2 5/8%** | **5 5/8%** | **8 5/8%** | **2 5/8%** | **5 5/8%** | **8 5/8%** | **2 5/8%** | **5 5/8%** | **8 5/8%** | **2 5/8%** | **5 5/8%** | **8 5/8%** |
| Ring Levee + Environmental Enhancement Acreage | 1.40 | 1.23 | 1.12 | 2.07 | 2.26 | 2.43 | 2.85 | 3.28 | 3.66 | 2.54 | 2.25 | 2.06 | 3.77 | 4.13 | 4.47 | 5.18 | 6.01 | 6.73 |
| Floodplain Management + Environmental Enhancement Acreage | 1.10 | 0.98 | 0.91 | 1.77 | 1.99 | 2.20 | 2.55 | 3.01 | 3.42 | 1.95 | 1.74 | 1.62 | 3.15 | 3.55 | 3.93 | 4.54 | 5.36 | 6.10 |
| Detention Basins Only + Environmental Enhancement Acreage | 0.79 | 0.70 | 0.64 | 1.27 | 1.40 | 1.53 | 1.87 | 2.14 | 2.38 | 1.27 | 1.12 | 1.04 | 2.04 | 2.26 | 2.47 | 3.01 | 3.46 | 3.86 |
| Structural (without ring levee) + Environmental Enhancement Acreage | 0.76 | 0.72 | 0.70 | 1.07 | 1.17 | 1.26 | 1.47 | 1.63 | 1.79 | 1.02 | 0.96 | 0.94 | 1.47 | 1.57 | 1.69 | 2.01 | 2.20 | 2.39 |
| Nonstructural (without floodplain management) + Environmental Enhancements Acreage | 0.87 | 0.89 | 0.90 | 1.10 | 1.19 | 1.25 | 1.36 | 1.49 | 1.59 | 1.04 | 1.04 | 1.04 | 1.49 | 1.65 | 1.78 | 2.01 | 2.27 | 2.46 |
| Combined (without ring levee and floodplain management) + Environmental Enhancement Acreage | 0.89 | 0.87 | 0.87 | 1.05 | 1.09 | 1.13 | 1.26 | 1.32 | 1.37 | 1.03 | 0.99 | 0.98 | 1.31 | 1.36 | 1.41 | 1.64 | 1.73 | 1.82 |
| Ring Levee | 13.19 | 10.91 | 9.27 | 13.19 | 10.91 | 9.27 | 13.19 | 10.91 | 9.27 | 15.91 | 13.10 | 11.09 | 15.91 | 13.10 | 11.09 | 15.91 | 13.10 | 11.09 |
| Floodplain Management | 8.94 | 6.36 | 5.15 | 8.94 | 6.36 | 5.15 | 8.94 | 6.36 | 5.15 | 8.94 | 6.36 | 5.15 | 8.94 | 6.36 | 5.15 | 8.94 | 6.36 | 5.15 |
| Environmental Enhancement Acreage | 0.52 | 0.54 | 0.56 | 1.24 | 1.64 | 1.96 | 2.08 | 2.74 | 3.27 | 0.98 | 1.02 | 1.06 | 2.35 | 3.11 | 3.74 | 3.92 | 5.21 | 6.25 |
| Nonstructural (without floodplain management) | 1.03 | 1.02 | 1.02 | 1.03 | 1.02 | 1.02 | 1.03 | 1.02 | 1.02 | 1.07 | 1.05 | 1.04 | 1.07 | 1.05 | 1.04 | 1.07 | 1.05 | 1.04 |
| Detention Basins | 1.27 | 0.96 | 0.78 | 1.32 | 1.01 | 0.83 | 1.51 | 1.16 | 0.95 | 1.62 | 1.24 | 1.02 | 1.68 | 1.30 | 1.08 | 1.93 | 1.49 | 1.23 |
| Combined (without ring levee and floodplain management) | 0.99 | 0.95 | 0.94 | 1.00 | 0.96 | 0.95 | 1.03 | 0.98 | 0.96 | 1.04 | 0.98 | 0.96 | 1.07 | 1.00 | 0.98 | 1.12 | 1.03 | 0.99 |
| Structural (without ring levee) | 0.93 | 0.84 | 0.79 | 0.95 | 0.86 | 0.82 | 1.03 | 0.91 | 0.86 | 1.03 | 0.93 | 0.90 | 1.08 | 0.97 | 0.92 | 1.17 | 1.02 | 0.95 |

The one exception is the environmental enhancements. The ratio for the enhancements decreased with a lower discount rate and increased with a higher discount rate. The reason for this result is that the only stream of benefits or costs that was subject to discounting was O&M. The per-acre habitat benefit, whether based on the Natomas Basin projects or the conservation bank credit price, represents the present value of the habitat. Recreation benefits were not assumed; therefore, there was no stream of recreation benefits in the analysis. The construction and land costs were assumed to be paid as one-time, upfront costs and, therefore, were not subject to discounting. The O&M costs, when subjected to the lower discount rate yielded a present value that was higher, while the habitat benefits and capital and land costs remained the same. This caused the benefit/cost ratio to decrease. Conversely, when the discount rate increased to 8 5/8 percent, the present value of the stream of O&M costs decreased and yielded a higher benefit/cost ratio.

There were only minor changes in the ordinal rankings of the alternatives and measures relative to the 5 5/8 percent discount rate. The vast majority of the ordinal rankings remained the same across the range of discount rates. The changes in ranking occurred in the bookend scenarios of low benefits/high costs and low costs/high benefits, which would be expected. The sensitivity analysis indicated that under the average benefits/high costs, high benefits/high costs, low benefits/low costs, and average benefits/high costs scenarios the change in discount rate caused changes in feasibility. These changes were also minor, with differences in the ratios measured mostly in the hundredths. The largest changes in the numeric ratios occurred again in the bookend scenarios. Overall, the BCA is consistent across the range of discount rates.

For the ring levee and the floodplain management flood control measures, inclusion of some omitted costs could change the relative ranking of the benefit/cost ratios. The ring levee cost estimates do not include downstream impacts, which if large could significantly decrease the benefit/cost ratio. For the floodplain management measure, the potential of associated costs to bring structures up to current building codes could significantly raise the costs of that measure.

Table 11 summarizes the sensitivity analysis ratios for each Draft EIR alternative and the subsets of the flood control measures examined for this BCA.

# References

American Society of Farm Managers and Rural Appraisers. 2003. 2003 Trends in Agricultural Land and Lease Values Region One Sacramento & Intermountain Values available at http://www.calasfmra.com/landvalues/2003/index.html. Accessed on May 28, 2004.

Boyer, T. and S. Polasky. 2004. "Valuing Urban Wetlands: A Review of Non-Market Valuation Studies." Unpublished Manuscript, Department of Applied Economics, University of Minnesota, St. Paul, MN. 55108.

Bryant, Tim/Associate Governmental Program Analyst, California Department of Conservation Division of Land Resource Protection. 2004. Personal communication with Nancy Lee/CH2M HILL. August 19.

CH2M HILL. 2004a. *Environmental Benefit Assessment of the Seymour-Johnson Air Force Base*. Confidential Draft Report prepared for Department of Defense.

CH2M HILL. 2004b. *Role of Land Transfers in Offsetting Environmental Liabilities: Applying a Net Environmental Benefit Analysis Approach.* Draft Report prepared for Confidential Client.

CH2M HILL. 2003. *Colusa Basin Drainage District Integrated Watershed Management Plan Draft Environmental Impact Report.* July.

Cowdin, Steve/Research Program Analyst II, Division of Planning and Assistance, DWR. 2004. Personal communication with Nancy Lee/CH2M HILL. November 12.

Federal Emergency Management Agency (FEMA). 1998. *Homeowner's Guide to Retrofitting Six Ways to Protect Your House from Flooding.* Washington, DC. June.

Freeman, A. Myrick. 1993. *The Measurement of Environmental and Resource Values Theory and Methods.* Resources for the Future, Washington, D.C.

Gustafson, John/State Rangeland Management Specialist, Natural Resource Concertino Service. 2004. Personal communication with Nancy Lee/CH2M HILL. September 14.

Heimlich, R. E., K. D. Wiebe, R. Claassen, D. Gadsby, and R. M. House. 1999. *Wetlands and Agriculture: Private Interests and Public Benefits.* Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 765.

King, D. and C. Bohlen. 1994. "Estimating the Costs of Restoration." *National Wetlands Newsletter* 16: 3-8.

Landes, Carol/Marketing Director, Wildlands, Inc. 2004a. Personal communication with Nancy Lee/CH2M HILL. June 1.

Landes, Carol/Marketing Director, Wildlands, Inc. 2004b. Personal communication with Nancy Lee/CH2M HILL. August 25.

Rosenberger, R. and J. B. Loomis. 2001. *Benefit Transfer of Outdoor Recreation Use Values: A Technical Report Document Supporting the Forest Service Strategic Plan* (2000 revision). General Technical Report. RMRS-GTR-72. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 59.

State of California. 2000. "Memorandum on Issues Pertaining to Wetland Mitigation Banks." prepared by the Board of Equalization Legal Division - MIC-82, from Kristine Cazadd, Senior Legal Council to Mr. Richard Johnson, Deputy Director. May 4, 2000.

U.S. Army Corps of Engineers (USACE). 2004. Federal Discount Rate FY 2004 available at http://www.usace.army.mil/inet/functions/cw/cecwp/General_guidance/guidance.htm. Accessed on August 20, 2004.

U.S. Census Bureau. 2004. Census 2000 Summary File 3 (SF-3) – Sample Data available at http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=DEC&_lang=en&_ts=. Accessed on October 9.

U.S. Fish and Wildlife Service (USFWS). 2004. Conservation Bank List available at http://sacramento.fws.gov/es/bank_list.htm. Accessed on May 20, 2004.

U.S. Fish and Wildlife Service (USFWS). No date. *Sacramento National Wildlife Refuge Complex Environmental Education Program Guide*.

Wildlands, Inc. 2003. *The Natomas Basin Conservancy Revised Site-specific Management Plans for the Natomas Basin Conservancy's Mitigation Lands Sacramento and Sutter Counties, California.* June 4.